15. ASSESSMENT OF GULF OF ALASKA ATKA MACKEREL

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EXECUTIVE SUMMARY

Relative to the November 2003 SAFE report, (GOA Atka mackerel are assessed biennially), the following substantive changes have been made in the current draft of the Atka mackerel chapter:

Changes in the Input Data

1. Catch data are updated.
2. Length and age data from the 2003 and 2004 GOA fisheries are presented.
3. Biomass estimates from the 2003 and 2005 GOA bottom trawl surveys are presented.
4. Length frequency data from the 2005 GOA bottom trawl survey are presented.

Changes in the Assessment Methodology

Gulf of Alaska Atka mackerel have been managed under Tier 6 specifications since 1996 due to lack of reliable estimates of current biomass. This year, Tier 5 calculations of ABC and OFL (based on 2005 survey biomass estimates) are presented for consideration.

Changes in Assessment Results

Since 1996, the *maximum permissible* ABC has been 4,700 mt under Tier 6. However, ABC has been set lower than 4,700 mt (1000 mt in 1997 and 600 mt for 1998-2005) for conservation reasons to allow for bycatch needs of other trawl fisheries and minimize targeting. The recommended 2006 ABC (under Tier 6) is increased to 1000 mt to accommodate an increase in GOA Atka mackerel, and still allow for bycatch in other directed fisheries and minimize targeting.

The maximum permissible ABC (22,700 mt) and the OFL (30,270 mt) under Tier 5 are presented for consideration, but are not recommended because they are based on highly variable survey biomass estimates (Gulf-wide *CV* of 50%), and catches of GOA Atka mackerel are mainly comprised of a single cohort (1999 year class).

Response to SSC comments

Comments Specific to the Atka Mackerel Assessment

There were no SSC comments pertaining to the Atka mackerel assessment from the December 2004 SSC minutes.

SSC Comments on Assessments in General

From the December 2004 SSC minutes: *"In its review of the SAFE chapter, the SSC noted that there is variation in the information presented. Several years ago, the SSC developed a list of items that should be included in the document. The SSC requests that stock assessment authors exert more effort to address each item contained in the list."* The authors made a concerted effort to follow the SAFE Guidelines.

Introduction

Distribution: Atka mackerel (*Pleurogrammus monopterygius*) are distributed along the continental shelf in areas across the North Pacific Ocean and Bering Sea from Asia to North America. On the Asian side they extend from the Kuril Islands to Provideniya Bay (Rutenberg 1962). Moving eastward, they are distributed throughout the Komandorskiye and Aleutian Islands, north to the Pribilof Islands in the eastern Bering Sea, and eastward through the Gulf of Alaska to southeast Alaska. Their center of abundance in Alaska, according to The Alaska Fisheries Science Center (AFSC) resource assessment surveys is the Aleutian Islands, particularly from Buldir Island to Seguam Pass.

An Atka mackerel population existed in the Gulf of Alaska (GOA) primarily in the Kodiak, Chirikof, and Shumagin areas, and supported a large foreign fishery through the early 1980s. By the mid-1980s, this fishery, and presumably the population, had all but disappeared. Evidence of low population levels was supported by Atka mackerel bycatch in other fisheries of less than 5 mt prior to 1988. The decline of the GOA Atka mackerel fishery suggests that the area may be the edge of the species' range. During periods of high recruitment in the Aleutian Islands, it is thought that juvenile Atka mackerel may move into the Gulf of Alaska under favorable conditions (Ronholt 1989, Lowe et al. 2005). Recently, Atka mackerel have been detected by the summer trawl surveys primarily in the Shumagin (Western) area of the Gulf of Alaska.

Early life history: Until recently, very little has been documented of the early life history of Atka mackerel prior to their appearance in trawl surveys and the fishery at about age 2-3 years. Eggs develop on rocky substrate at depth. Gorbunova (1962) reported that the incubation time for eggs was from 40-45 days, but was not specific about the temperature at which eggs were incubated. Researchers from the Alaska Sea Life Center (ASLC) and University of Alaska Fairbanks (UAF) conducted laboratory experiments to determine the effect of water temperature on incubation rates of Atka mackerel eggs, and found that they ranged from 40 days at 10°C to 105 days at 4°C days (Jared Guthridge ASLC and Nicola Hillgruber UAF, *pers. comm*.). Atka mackerel larvae are found primarily in the neuston from fall through spring and reach maximum abundance in late October (Kendall and Dunn 1985). The mean length of larvae increases from 10.3 mm in the fall to 17.6 mm in the spring (Kendall and Dunn 1985). Larvae can be carried great distances to offshore waters (Gorbunova 1962).

Reproductive ecology: Atka mackerel are sexually dichromatic (Medveditsyna 1962, Rutenberg 1962) and sexually dimorphic (Zolotov 1981). They have a polygamous mating system and are obligate demersal spawners with male parental care. Molecular genetics is being used to study the mating system of Atka mackerel in more detail and early indications are that it is complex and most likely involves alternative reproductive strategies resulting in multiple parentage in a single egg clutch (Mike Canino AFSC, *pers. comm*). Spawning and nesting has been observed to occur as shallow as 10 m (Gorbunova 1962) and as deep as 143 m (Lauth et al. *in review*). Possible factors limiting the upper and lower depth limit of Atka mackerel spawning and nesting include kelp, green sea urchins, wave surge, water clarity, light penetration, and temperature (Lauth et al. *in review*, Gorbunova 1962, Zolotov 1993). Spawning begins in June and lasts through October (Gorbunova 1962, Zolotov 1993, McDermott and Lowe 1997, Dan Cooper AFSC, *pers. comm.*). Adhesive eggs are laid on rocky substrates in areas with moderate or strong current in water temperatures ranging from 3.9°C to 10.5°C (Gorbunova 1962, Lauth et al. *in review*). Males exhibiting nesting colors and behaviors begin aggregating at nesting sites in June. In Alaska, nesting sites were observed in the continental shelf regions from Stalemate Bank in the Aleutian archipelago to Unga Island in the Gulf of Alaska. The high abundance of larvae observed offshore of Kodiak Island in the 1970's suggests that nesting grounds have historically extended even further to the east. Males probably remain aggregated at nesting sites into November or December because spawning occurs through October (McDermott and Lowe 1997) and eggs require a minimum of 40 days to incubate (Gorbunova 1962).

Prey and predators: Diets of commercially important groundfish species in the Gulf of Alaska during the summer of 1990 were analyzed by Yang (1993). Although Atka mackerel were not sampled as a predator species, it can be inferred that the major prey items of Gulf of Alaska Atka mackerel would likely be euphausiids and copepods as found in Aleutian Islands Atka mackerel (Yang, 1999). The abundance of Atka mackerel in the Gulf of Alaska is much lower compared to the Aleutian Islands. Atka mackerel only showed up as a minor component in the diet of arrowtooth flounder in the Gulf of Alaska (Yang, 1993). Adult Atka mackerel in the Aleutians are consumed by a variety of piscivores, including groundfish (e.g., Pacific cod and arrowtooth flounder, Livingston et al., unpubl. manuscr.), marine mammals (e.g., northern fur seals and Steller sea lions, Kajimura 1984, NMFS 1995, Sinclair and Zeppelin 2002), and seabirds (e.g., thick-billed murres, tufted puffins, and short-tailed shearwaters, Springer et al. 1999).

Nichol and Somerton (2002) examined the diurnal vertical migrations of Atka mackerel using archival tags and related these movements to light intensity and current velocity. Atka mackerel displayed strong diel behavior, with vertical movements away from the bottom occurring almost exclusively during daylight hours, presumably for feeding, and little to no movement at night (where they were closely associated with the bottom).

Stock structure: A morphological and meristic study suggested that there may be separate populations in the Gulf of Alaska and the Aleutian Islands (Levada 1979). This study was based on comparisons of samples collected off Kodiak Island in the central Gulf, and the Rat Islands in the Aleutians. Lee (1985) also conducted a morphological study of Atka mackerel from the Bering Sea, Aleutian Islands and Gulf of Alaska. The data showed some differences (although not consistent by area for each characteristic analyzed), suggesting a certain degree of reproductive isolation. Results from an allozyme genetics study comparing Atka mackerel samples from the western Gulf of Alaska with samples from the eastern, central, and western Aleutian Islands showed no evidence of discrete stocks (Lowe et al. 1998). However, more recent analyses using molecular genetics to evaluate genetic structuring of Atka mackerel have found evidence of stock structure (Canino et al. *in review*). A preliminary survey of genetic variation in Atka mackerel using microsatellite DNA markers provided evidence of population structuring over modest geographic scales (North of Akun Island out to Stalemate Bank). These findings contrast with results from the earlier study using allozymes (Lowe et al. 1998), which showed no evidence for genetic differentiation in Atka mackerel over the same geographic range. Results are concordant with earlier studies indicating potential stock differentiation based upon morphometric characters. The analyses clearly indicate some degree of genetic stock differentiation, and thus self-recruitment in the Aleutian Islands at more localized scales than are currently realized. Analyses are currently underway to evaluate samples recently collected from the Gulf of Alaska and Japan.

Management units: Gulf of Alaska Atka mackerel are managed as a Gulf-wide species and managed separately from the Bering Sea/Aleutian Islands. The question remains as to whether the Aleutian Island (AI) and Gulf of Alaska populations of Atka mackerel should be managed as a unit stock or separate populations. There are significant differences in population size, distribution, recruitment patterns, and resilience to fishing that suggest that management as separate stocks is appropriate. Bottom trawl surveys and fishery data suggest that the Atka mackerel population in the GOA is smaller and much more patchily distributed than that in the AI, and composed almost entirely of fish >30 cm in length. There are also more areas of moderate Atka mackerel density in the AI than in the GOA. The lack of small fish in the GOA suggests that Atka mackerel recruit to that region differently than in the AI. Nesting sites have been located in the Gulf of Alaska in the Shumagin Islands (Lauth et al. *in review*), and historical ichthyoplankton data from the 1970's around Kodiak Island definitely indicate there was a spawning and nesting population even further to the east (Kendall and Dunn 1985), but the source of these spawning populations is unknown. They may be migrant fish from strong year classes in the Aleutian Islands or a self-perpetuating population in the Gulf, or some combination of the two. The idea that the western GOA is the eastern extent of their geographic range might also explain the greater sensitivity to fishing

depletion in the GOA as reflected by the history of the GOA fishery since the early 1970s. Catches of Atka mackerel from the GOA peaked in 1975 at about 27,000 mt. Recruitment to the AI population was low from 1980-1985, and catches in the GOA declined to 0 in 1986. Only after a series of large year classes recruited to the AI region in the late 1980s, did the population and fishery reestablish in the GOA beginning in the early 1990s. After passage of these year classes through the population, the GOA population, as sampled in the 1996 and 1999 GOA bottom trawl surveys, has declined and is very patchy in its distribution. Most recently, the strong 1998 and 1999 year classes documented in the Aleutian Islands showed up in the Gulf of Alaska. Leslie depletion analyses using historical AI and GOA fishery data suggest that catchability increased from one year to the next in the GOA fished areas, but remained the same in the AI areas (Lowe and Fritz 1996; 1997). These differences in population resilience, size, distribution, and recruitment argue for separate assessments and management of the GOA and AI stocks while we await results from microsatellite DNA studies.

Fishery

Catch History and Fishery Management

Prior to the mid-1980s, Atka mackerel were fished exclusively by foreign vessels, primarily from the Soviet Union. Landings were about 19,500 mt in 1977 and 1978, then dropped to less than 5 mt in 1986 (Table 15.1). Some joint venture operations participated in this fishery from 1983 to 1985. All landings since then have been taken by the domestic fishery.

In 1988, Atka mackerel were combined in the Other Species category due to low abundance and the absence of a directed fishery for the previous several years. However, beginning in 1990, Atka mackerel were targeted in the western Gulf of Alaska. From 1990-1993, catches of the Other Species category in the GOA were dominated by Atka mackerel, primarily from the Western GOA regulatory area. Atka mackerel were separated from the other species category and became a separate target category in the GOA in 1994, after approval of Amendment 31 to the Fishery Management Plan for the Groundfish Fishery of the Gulf of Alaska. Recent catches of Atka mackerel by GOA management areas have been:

Gulf of Alaska (GOA) Catches (mt) by Management Areas

Year	Western	Central	Eastern	Total
1990a	1,416	0	0	1,416
1991	3,249	9	0	3,258
1992	13,785	49	0	13,834
1993	4,867	2,143	0	7,010
1994	2,661	877	0	3,538
1995	329	370	2	701
1996	1,577	9	0	1,586
1997	321	8	2	331
1998	279	38	0	317
1999b	-	-	-	262
2000	-	-	-	170
2001	-	-	-	76
2002	-	-	-	85
2003	-	-	-	578
2004	-	-	-	818
2005c	-	-	-	881

a/ Actual observed catch
b/ TAC was set GOA-wide; catches not available by regulatory area from NMFS Alaska Regional Office.
c/ 2005 data as of 29-OCT-05 from NMFS Alaska Regional Office. Available at http://www.fakr.noaa.gov/2005/car110_goa.pdf

The 1990 catch of 1,416 mt is a minimum estimate, since this was the tonnage actually observed by domestic observers. The Alaska Regional Office's estimate of catch for 1990 is underestimated, as Gulf of Alaska Atka mackerel catches were incorrectly being reported as landed in the Aleutian Islands (G. Tromble, Regional Office, Juneau, Alaska, *pers. comm.*). Total catches of Atka mackerel were small until 1992, when approximately 14,000 mt were taken in the Shumagin area. In 1994 when Atka mackerel was taken out of the Other Species category and assigned a target species, the North Pacific Fishery Management Council (Council) assigned a Gulf-wide Atka mackerel ABC and TAC of 4,800 and 3,500 mt, respectively (Table 15.1). For 1995 and 1996, the Council approved a Gulf-wide ABC and a total TAC of 3,240 mt for Gulf of Alaska Atka mackerel (Table 15.1). For purposes of data collection and effort dispersion, 2,310 mt was allocated to the Western or Shumagin subarea (Area 610), 925 mt was allocated to the Central, or the combined Chirikof and Kodiak subareas (Areas 620 and 630), and 5 mt was assigned to the Eastern GOA (Areas 640 and 650). The Western subarea (Area 610) was not opened to the directed Atka mackerel fishery in 1995 because the overfishing level for Pacific ocean perch (POP) was nearly reached; Atka mackerel fisheries have had significant bycatch of POP (A. Smoker, NMFS, Juneau, Alaska, *pers. comm.*). In 1996, the fishery in the Western subarea was restricted to a 12-h opening on July 1, again due to concerns about the POP bycatch exceeding the POP TAC and approaching the overfishing level; about 1,600 mt of Atka mackerel were caught. The 1996 Central POP catch exceeded the Central area POP overfishing level, thus there was no opening for the directed Atka mackerel fishery in that area. Since 1997 the Atka mackerel fishery has been managed as a bycatch-only fishery with Gulf-wide TACs of 1,000 mt in 1997 and 600 mt for the years 1998 to 2005.

The catch of GOA Atka mackerel jumped dramatically in 2003 to 578 mt. Previous to this, catches were less than 100 mt in 2001 and 2002 (Table 15.1). The 2004 Gulf-wide Atka mackerel catch of 818 mt, exceeded the TAC (600 mt) for Atka mackerel for the first time since this quota was implemented in 1998. The 2005 catch (881 mt as of 10/29/05) also exceeded the 2005 Atka mackerel TAC. This increase of Atka mackerel in the GOA coincided with local sports fishermen reporting catches of Atka mackerel for the first time off Resurrection Bay and as far as Southeast Alaska in 2003. The 1999 year class has been documented as a very strong year class in the Aleutian Islands (Lowe et al. 2005). Twenty seven Atka mackerel were sampled for otoliths by observers in the 2003 Gulf of Alaska fisheries. All 27 fish were aged and determined to be 4-year olds of the 1999 year class. Sixteen fish were sampled for otoliths by observers in the 2004 Gulf of Alaska fisheries, and 12 of those fish were determined to be 5-year olds of the 1999 year class

Figure 15.1 shows the 2003, 2004, and 2005 distributions of observed catches of Atka mackerel in the Gulf of Alaska summed by 20 km areas. Most of these catches occurred during July through October. Open circles represent observed catches greater than 1 mt. Large catches were observed in the Shumagin and Chirikof areas. Many of these large catches were retained. It is apparent that fishermen were encountering large enough quantities to allow for some targeting of Atka mackerel. The small closed circles represent observed catches less than 1 mt and probably represent true bycatch. It is notable that observations of small catches of Atka mackerel in 2003 and 2004 extended well into the Kodiak area.

Description of the Directed Fishery

There has not been a directed fishery for Atka mackerel since 1996. A discussion of the directed fishery for the years 1990-1994 is given in Lowe and Fritz (2001). However, there appears to be some targeting of Atka mackerel in the Western and Central Gulf of Alaska beginning in 2003 (see discussion above).

Bycatch and Discards

A discussion of the historical amount of Atka mackerel retained and discarded by target fishery and area in the Gulf of Alaska in 1994 and 1995 has been given in previous assessments (Lowe and Fritz, 2000 and Lowe and Fritz 2001). The 2003 and 2004 levels of Gulf of Alaska Atka mackerel retained and discarded are given below:

Year	Fishery	Discarded (mt)	Retained (mt)	Total (mt)
2003	Rockfish	211.8	210.6	422.4
	All others	37.2	118.6	155.8
	All	249.0	329.2	578.2
2004	Rockfish	258.6	461.0	719.6
	All others	69.3	29.4	98.7
	All	327.9	490.4	818.3

The 2003 and 2004 data indicated that most of the Atka mackerel bycatch in the GOA, which is coming out of the Shumagin and Chirikof areas, was taken in the rockfish fisheries. The amount of Atka mackerel retained in the rockfish fishery more than doubled in 2004. There appears to have been targeted fishing on Atka mackerel. In 2003 the flatfish fishery retained a significant amount of Atka mackerel. There was very little Atka mackerel retained by fisheries than rockfish in 2004.

Fishery Length Frequencies

Atka mackerel length distributions from the 1990-1994 fisheries are discussed in previous assessments (Lowe and Fritz 2001). In 2003 and 2004, observers were able to take a limited number of length frequency measurements of Atka mackerel in the Shumagin area. The distribution of fish lies mainly between 37 to 45 cm with modes at 41 and 43 cm in 2003 and 2004, respectively (Figure 15.2).

Fishery Age Frequencies

There is only very limited age data available from the 1990 Davidson Bank fishery, the 1992 Umnak Island fishery and the 1994 fishery which operated off Umnak Island, Davidson Bank and Shumagin Bank. These data are discussed in Lowe and Fritz (2001).

Twenty seven Atka mackerel were sampled for otoliths by observers in the 2003 Gulf of Alaska fisheries. All 27 fish were aged and determined to be 4-year olds of the 1999 year class. Sixteen fish were sampled in the 2004 Gulf of Alaska Fisheries, and 16 of those 27 fish were determined to be 5-year olds of the 1999 year class (Figure 15.3).

Fishery and Steller Sea Lions

The western stock of Steller sea lions, which ranges from Cape Suckling (at 144°W) west through the Aleutian Islands and into Russia, is currently listed as endangered under the Endangered Species Act (ESA), and has been listed as threatened since 1990. In 1991 and 1992, 10 nm annual trawl exclusion zones were established around all rookeries west of 150°W (Figure 15.1); in 1992 and 1993, 20 nm trawl exclusion zones were established around 6 rookeries in the eastern Aleutian Islands that are operational only during the BSAI pollock A-season. In 1993, NMFS designated Steller sea lion critical habitat, which includes a 20 nm aquatic zone around all rookeries and major haulouts west of 144°W, and three foraging areas, one of which contains Shelikof Strait. Sea lion food habits data collected in the Aleutian Islands revealed that Atka mackerel was the most common prey of Steller sea lions throughout the year (NMFS 1995, Sinclair and Zeppelin 2002).

From 1977 to 1984 and in 1990, 0-11% of the annual Gulf of Alaska Atka mackerel harvest was caught within 20 miles of all Gulf of Alaska sea lion rookeries and major haulouts, reflecting the offshore distribution of the fishery. In 1991-1993, however, the fishery moved closer to shore, and this percentage

increased to 82-98%, almost all of which was caught between 10-20 nm of Steller sea lion rookeries on Ogchul and Adugak Islands (near Umnak Island), and Atkins and Chernabura Islands in the Shumagin Islands.

Leslie depletion estimates of local fishery harvest rates were much greater than estimated Gulf-wide harvest rates (Lowe and Fritz 1996; 1997). This could have adversely affected Steller sea lion foraging success, which raised concerns about how the fishery may have affected food availability and the potential for recovery of the Steller sea lion population. There has not been a directed Gulf of Alaska Atka mackerel fishery since 1996. In June 1998, the Council passed a fishery regulatory amendment which proposed a four-year timetable to temporally and spatially disperse and reduce the level of Atka mackerel fishing within Steller sea lion critical habitat in the Bering Sea/Aleutian Islands. The regulations implementing this four-year phased-in change to Atka mackerel fishery management became effective on 22 January 1999 and lasted only 3 years (through 2001). In 2002, new regulations affecting management of the Atka mackerel, pollock, and Pacific cod fisheries went into effect. The management of the Bering Sea/Aleutian Islands Atka mackerel fishery is detailed in Lowe et al. (2005).

Survey Data

Absolute Abundance and Survey Biomass

Bottom trawl surveys of the Gulf of Alaska groundfish community have been conducted every three years since 1984 and biennially since 1999 using an area-depth stratified and area-swept design. In 1999, the same GOA survey design was maintained, but effort allocation was shifted to provide more even coverage within depth strata. Atka mackerel are a very difficult species to survey because: (1) they do not have a swim bladder, making them poor targets for hydroacoustic surveys; (2) they prefer hard, rough and rocky bottom which makes sampling with the standard survey bottom trawl gear difficult; and (3) their schooling behavior and patchy distribution makes the species susceptible to large variances in catches which greatly affect area-swept estimates of biomass.

The general groundfish surveys of the Gulf of Alaska are particularly problematic for Atka mackerel given the characteristics described above. In 1996, a meaningful estimate of biomass could not be determined from the data due to extreme variances. Over 98% of the Atka mackerel caught in the 1996 survey were encountered in a single haul within a large stratum, which yielded a large stratum biomass with an extremely large confidence interval.

Although estimates of abundance from earlier surveys have been presented in previous assessments, they were also compromised by the problem of large confidence intervals, although not to the same degree as observed in 1996. Similar to the 1996 survey, virtually all the GOA Atka mackerel biomass from the 2001 survey was encountered in a single haul south of the Islands of Four Mountains (Figure 15.4). Atka mackerel have been inconsistently caught in the GOA surveys, appearing in 5%, 28%, 13%, 20%, 10%, 44%, and 29% of the hauls in the Shumagin area in the 1990, 1993, 1996, 1999, 2001, 2003, and 2005 GOA surveys, respectively. What can be concluded from this is that the general groundfish GOA bottom trawl survey, as it has been designed and used since 1984, does not assess Atka mackerel well and the resulting biomass estimates are not considered consistent reliable indicators of absolute abundance or as indices of trend.

However, the 2003 Gulf of Alaska bottom trawl survey encountered the highest percentage of hauls with Atka mackerel catch since 1990. Catches were less patchy relative to previous surveys, and observations extended into the Central Gulf of Alaska (Figure 15.4). This is coincident with dramatically increased catches of Atka mackerel in other directed fisheries, and reports from local sports fishermen of catches of Atka mackerel in the Central Gulf and even off Southeast Alaska. The 2004 survey encountered fewer hauls with Atka mackerel catch (relative to the 2003 survey), but similar to the rate of encounter in the

1993 survey. Observations extended only into the Chirikof area (Figure 15.4). As such, bottom trawl survey information is presented for 2003 and 2005 for consideration (Table 15.2).

Most of the GOA Atka mackerel biomass (91% and 96% in 2003 and 2005, respectively) is distributed within the Shumagin area of the Western GOA (Area 610, Figure 15.4, Table 15.2). Atka mackerel were encountered in 29% of the hauls conducted in the Shumagin area in the 2005 survey. The 2005 estimate of Atka mackerel biomass in the Shumagin area is 97,200 mt, with a coefficient of variation (*CV*) of 51% (reflecting a variance of 2.5 million), and a 95% confidence interval ranging from 0-198,285 mt (Table 15.2).

Survey Length Frequencies
Length frequency distributions from the 2003 and 2005 surveys are shown in Figure 15.5. The distributions of fish from the surveys fall mainly between 35 and 45 cm in 2003 and 40 and 45 cm in 2005, with modes at 39 cm in 2003 and 43 cm in 2004 (Figure 15.5). Mean lengths for males and females, respectively, from each survey are: 38.7 and 39.9 cm in 2003, and 42.7 and 43.4 cm in 2005 (Figure 15.5).

It is interesting to note that the length frequency distributions of males and females differ slightly in the GOA surveys. The female length frequency distributions show a slightly greater proportion of large fish, while the male distributions show slightly greater proportions of small fish (Figure 15.5). This has not been observed in the Aleutian Islands surveys; the male and female length frequency distributions are not differentiable and survey length frequency distributions are presented for combined sexes (Lowe et al. 2005).

Survey Age Frequencies
Historical survey age data from the Gulf of Alaska trawl survey are only available from 1993 (Figure 10.11 in Lowe and Fritz 2001). The 1993 survey showed a mode of 5-year olds from the 1988 year class which has also been documented as a strong year class in the Aleutian Islands (Lowe et al. 2005).

The 2003 Gulf of Alaska survey was able to sample a large amount of Atka mackerel, and 482 otoliths were aged (Figure 15.6). The 2003 survey age data show that the survey catches were comprised mainly of 4-year-olds from the 1999 year class (63%), followed by significant numbers of 5-year-olds from the 1998 year class (20%). The 1998 and 1999 year classes are documented to be well above average in the Aleutian Islands assessment (Lowe et al. 2005).

Biological Parameters

Natural Mortality, Age of Recruitment, and Maximum Age
A natural mortality rate of 0.3 is assumed for Gulf of Alaska Atka mackerel based on Aleutian Islands Atka mackerel (Lowe et al. 2005).

A qualitative look at the sparse GOA fishery age data shows recruitment patterns similar to the Aleutian Islands fishery. The age of first recruitment appears to be 2-3 years, and full recruitment at 4 years (Lowe and Fritz 2001). This pattern becomes somewhat obscured when a strong year class dominates the distributions.

The maximum age seen in the Gulf of Alaska fishery is 13 years (1990 fishery). This compares with a maximum age of 15 years for the Aleutian Islands.

Length and Weight at Age
Parameters of the von Bertalanffy length-age equation and a weight-length relationship were calculated from the combined 1990, 1992, and 1994 fishery data. Sexes were combined to provide an adequate sample size. The estimated von Bertalanffy growth parameters are:

L_∞ = 54.56 cm
K = 0.22
t_0 = -2.78 yr

Length-age equation: Length (cm) = $L_\infty\{1-\exp[-K(\text{age}- t_0)]\}$.

The weight-length relationship was determined to be:

Weight (kg) = 4.61E-05*Length (cm) 2.698.

Growth parameters were also estimated from data collected during the 1993 Gulf of Alaska survey. As in the Aleutians, the survey tends to select for smaller fish at age than the fishery. The estimated von Bertalanffy parameters from the 1993 survey are:

L_∞ = 47.27 cm
K = 0.610
t_0 = 0.38 yr.

The estimated weight-length relationship is:

Weight (kg) = 1.55E-05*Length (cm) 2.979.

The age-length and weight-length schedules for the fishery and survey are given in Table 15.3.

Maturity at Length and Age
Female maturity at length and age were determined for Gulf of Alaska Atka mackerel (McDermott and Lowe 1997). The maturity schedules are given in Table 15.4. The age at 50% maturity is 3.6 years and length at 50% maturity in the Gulf of Alaska is 38.2 cm.

Selectivity at Age
The small amount of age data for Gulf of Alaska Atka mackerel show similar selectivity patterns as seen in the Aleutian survey and fishery data. The fishery data tend to show older fish than the survey samples. The oldest age from the 1993 GOA survey was 9 years old and the age distribution consisted of mostly 2-6 year olds (Lowe and Fritz 2001). Recent age data from the fishery (2004) and survey (2003) show a very limited distribution of ages (Figures 15.3 and 15.6). Current catches of Atka mackerel are mainly comprised of a single cohort, the very strong 1999 year class.

Overfishing Level and Maximum Permissible ABC

If there is no reliable estimate of current biomass, then Tier 6 of Amendment 56 of the GOA FMP defines the overfishing level (OFL) as the average catch from 1978-95, and the maximum permissible ABC as 0.75 of the OFL. The average annual catch from 1978-95 is 6,200 mt, which is the overfishing level, and the maximum permissible ABC is 4,700 mt under Tier 6.

However, as noted above, bottom trawl survey information from the 2003 and 2005 surveys is presented for consideration. The 2005 survey estimated a GOA Atka mackerel biomass of 100,913 mt with a *CV* of 50%. If this current estimate of Atka mackerel biomass is considered reliable, and a reliable estimate of natural mortality (M) exists, then Tier 5 of Amendment 56 of the GOA FMP defines the fishing mortality rate used to set OFL (F_{OFL}) as $F_{OFL} = M$, and the maximum permissible fishing mortality rate used to set ABC (F_{ABC}) as 0.75 of M. The natural mortality rate is assumed to be 0.3, thus F_{OFL} = 0.3, and the OFL

would be 30,270 mt (0.3 x 100,913 mt) under Tier 5. The maximum permissible F_{ABC} is equal to 0.225 (0.75 x 0.3), and the maximum permissible ABC is 22,700 mt (0.225 x 100,913 mt) under Tier 5.

ABC Considerations and Recommendation

Since 1996, GOA Atka Mackerel has been managed under Tier 6 specifications due to lack of reliable estimates of current biomass. The *maximum permissible* ABC has been 4,700 mt. However, ABC has been set lower than 4,700 mt (see Table 15.1) for the following reasons:

1. Even when ABCs were lower than 4,700 mt, such as in 1994 when the ABC was 3,280 mt, the fishery may have created localized depletions of Atka mackerel in the two primary fished areas, south of Umnak Island and southeast of the Shumagin Islands (see appendix in Lowe and Fritz 1996). The 1994 ABC was set using a 15% harvest rate applied to the 1993 survey biomass estimate of 21,600 mt. The two 1994 fisheries at Umnak and Shumagin combined for over 3,000 mt of the 3,500 mt caught that year, and harvest rates far exceeded the target 15% in each area: at Umnak, the harvest rate was estimated at 85%, and at Shumagin, the harvest rate was estimated at 91%. The 1990 and 1993 surveys also found that Atka mackerel in the GOA were principally congregated in these two areas used by the fishery. These data indicate that the fishery was very efficient in removing fish from these areas and at rates which far surpassed the target Gulf-wide harvest rate.
2. Analyses of historical local fishery CPUEs suggests that the Atka mackerel populations at Umnak and Shumagin Islands declined significantly between 1992 and 1994 (see appendix in Lowe and Fritz 1996). This also reflects the trend of the Aleutian Island Atka mackerel population during that period.
3. The GOA Atka mackerel population appears to be particularly vulnerable to fishing pressure because of its very patchy distribution and sporadic recruitment patterns. This is reflected in the Leslie depletion analyses (appendix in Lowe and Fritz 1996) and by the disappearance of the population in the mid-1980s following a period with annual catches as high as 27,000 mt.
4. Although there has been a dramatic increase in the observations of Atka mackerel in the 2003 GOA fisheries and survey, these catches (and catches from the 2004 GOA fisheries) are mainly comprised of a single cohort (the 1999 year class) which has been documented as well above average in the Aleutian Islands (Lowe et al. 2005). There does not appear to be an expanded population with a broad distribution of age classes, and speculation is that this is overflow from the Aleutian Islands population.
5. The biomass estimates from the 2005 survey are highly variable with a Gulf-wide *CV* of 50%. The Shumagin area had an estimated biomass of 97,200 mt (96% of the Gulf-wide estimate) with a *CV* of 51%.

Prudent management is still warranted and the rationale as given in the past for a TAC to provide for anticipated bycatch needs of other fisheries, principally for Pacific cod, rockfish and pollock, and to only allow for minimal targeting should still be considered.

For the above reasons, we continue to recommend that GOA Atka mackerel be managed under Tier 6, and recommend a 2006 ABC for GOA Atka mackerel sufficient to satisfy the bycatch needs of other trawl fisheries, a recommendation identical to that made since 1997. Catches of Atka mackerel in the GOA in 1997, 1998, 1999, 2000, 2001 and 2002 were only 331, 317, 262, 170, 76, and 85 mt, respectively, which could represent the natural bycatch of Atka mackerel in other groundfish fisheries during those years. The catches in 2003 and 2004 were 565 and 818 mt, respectively, which does appear to include some targeted catches. The 2005 catch of Atka mackerel as of 10/29/05 has reached 881 mt. Again, this does appear to include some targeted catches. Since 1997, a catch level of 600 mt has been considered a reasonable amount to allow for bycatch and minimize targeting. However due to the

increased observations of Atka mackerel in the Gulf of Alaska, we recommend a higher level to still allow for bycatch and minimize targeting. **We recommend a 2006 GOA Atka mackerel ABC of 1,000 mt**. **Under Tier 6, the 2006 OFL is 6,200 mt.**

Ecosystem Considerations

Steller sea lion food habits data (from analysis of scats) from the Aleutian Islands indicate that Atka mackerel is the most common prey item throughout the year (NMFS 1995, Sinclair and Zeppelin 2002). The prevalence of Atka mackerel and walleye pollock in sea lion scats reflected the distributions of each fish species in the Aleutian Islands region. The percentage occurrence of Atka mackerel was progressively greater in samples taken in the central and western Aleutian Islands, where most of the Atka mackerel biomass in the Aleutian Islands is located. Conversely, the percentage occurrence of pollock was greatest in the eastern Aleutian Islands. Steller sea lion food habits data from the western Gulf of Alaska are relatively sparse, so it is not known how important Atka mackerel is to sea lions in this area. The close proximity of fishery locations to sea lion rookeries in the western Gulf suggests that Atka mackerel could be a prey item at least during the summer. Analyses of fishery CPUE revealed that the fishery may create temporary localized depletions of Atka mackerel, and that these depletions may last for weeks after the vessels have left the area. This supports the argument already made above in the ABC section for a conservative harvest policy for Atka mackerel in the Gulf of Alaska.

Data Gaps and Research Priorities

Regional and seasonal food habits data for Gulf of Alaska Atka mackerel is very limited. Studies to determine the impacts of environmental indicators such as temperature regime on Atka mackerel are needed. Further studies to determine whether there have been any changes in life history parameters over time (e.g. maturity-at-age, fecundity, weight- and length-at-age) would be informative. More information on Atka mackerel habitat preferences would be useful to improve our understanding of Essential Fish Habitat (EFH), and improve our assessment of the impacts to habitat due to fishing. Better habitat mapping of the Gulf of Alaska would provide information for survey stratification and the extent of trawlable and untrawlable habitat.

Summary

Tier 6	Tier 5
M = 0.30	M = 0.30
Maximum permissible F_{ABC} = unknown	Maximum permissible F_{ABC} = 0.225
F_{OFL} = unknown	F_{OFL} = 0.30
2006 exploitable biomass = unknown	2006 exploitable biomass = 100,900 mt (2005 survey)
2006 overfishing level = 6,200 mt	2006 Overfishing level = 30,270 mt
2006 maximum permissible ABC = 4,700 mt	2006 maximum permissible ABC = 22,700 mt

Tier 6 recommended 2006 ABC = 1,000 mt

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Tables

Table 15.1 Gulf of Alaska Atka mackerel catches (including discards), and corresponding Acceptable Biological Catches (ABC) and Total Allowable Catches (TAC) set by the North Pacific Fishery Management Council from 1977 to the present. Catches, ABCs, and TACs are in mt.

Year	Catch	ABC	TAC
1977	19,455		22,000[f]
1978	19,588		24,800[f]
1979	10,949		26,800[f]
1980	13,166		28,700[f]
1981	18,727		28,700[f]
1982	6,760		28,700[f]
1983	12,260		28,700[f]
1984	1,153		28,700[f]
1985	1,848		5,000[f]
1986	4	4,700	4,678[f]
1987	1	0	240[g]
1988[a]	[b]		
1989	[b]		
1990	1,416[c]		
1991	3,258[c]		
1992	13,834[c]		
1993	5,146[c]		
1994[d]	3,538	4,800	3,500
1995	701	3,240	3,240
1996	1,580	3,240	3,240
1997	331	1,000	1,000
1998	317	600	600
1999	262	600	600
2000	170	600	600
2001	76	600	600
2002	85	600	600
2003	578	600	600
2004	818	600	600
2005[e]	881	600	600

a/ Atka mackerel were added to the Other Species category in 1988.
b/ Catches of Atka mackerel were included in the Other Species category.
c/ Catches of Atka mackerel was reported separately for 1990-1993.
d/ Atka mackerel were assigned a target species in 1994.
e/ 2005 data as of 29-OCT-05 from NMFS Alaska Regional Office. Available at http://www.fakr.noaa.gov/2005/car110_goa.pdf
f/ Reported as OY (Optimum Yield).
g/ Reported as TQ (Target Quota).

Table 15.2. Gulf of Alaska Atka mackerel mean biomass estimates (biomass, mt), variance, coefficient of variation (*CV*), lower and upper 95% confidence intervals (CI) about mean biomass, by area from the 2003 and 2005 Gulf of Alaska bottom trawl surveys. Number of hauls conducted in each area, and number and percentage (%) of hauls with Atka mackerel catch are also given.

Year	Area	Haul count	Hauls with catch*	% hauls with catch*	Biomass	Biomass variance	*CV*	Lower 95% CI	Upper 95% CI
2003	Shumagin	230	101	44%	59,373	442,743,545	35%	17,291	101,456
	Chirikof	172	12	7%	421	33,829	44%	37	804
	Kodiak	248	35	14%	5,224	9,333,815	58%	0	12,135
	Yakutat	79	9	11%	514	32,642	35%	134	893
	Southeast	80	0	0%	0	0		0	0
	Gulf of Alaska	809	157	19%	65,532	452,143,831	32%		
2005	Shumagin	180	53	29%	97,233	2,500,113,153	51%	0	198,285
	Chirikof	177	38	21%	2,533	473,332	27%	1,142	3,923
	Kodiak	293	9	3%	1,147	642,670	70%	0	2,750
	Yakutat	92	0	0%	0	0		0	0
	Southeast	97	0	0%	0	0		0	0
	Gulf of Alaska	839	100	12%	100,913	2,501,229,155	50%		

*Catch of Atka mackerel.

Table 15.3 Atka mackerel age-length and weight length schedules based on parameters estimated from combined 1990, 1992 and 1994 fishery data and the 1993 survey.

Fishery			Survey		
Age	Length	Weight	Age	Length	Weight
1	30.81	0.48	1	14.89	0.05
2	35.50	0.70	2	29.67	0.38
3	39.26	0.92	3	37.71	0.77
4	42.28	1.12	4	42.08	1.07
5	44.71	1.31	5	44.45	1.26
6	46.65	1.47	6	45.74	1.37
7	48.21	1.60	7	46.44	1.43
8	49.47	1.72	8	46.82	1.47
9	50.47	1.81	9	47.02	1.49
10	51.28	1.89	10	47.14	1.50
11	51.93	1.96	11	47.20	1.50
12	52.45	2.01	12	47.23	1.51
13	52.86	2.05	13	47.25	1.51
14	53.20	2.09	14	47.26	1.51
15	53.47	2.12	15	47.26	1.51

Table 15.4. Schedules of age and length specific maturity from McDermott and Lowe (1997).

Length (cm)	Proportion mature	Age	Proportion mature
20	0	1	0
21	0	2	0.04
22	0	3	0.22
23	0	4	0.69
24	0	5	0.94
25	0	6	0.99
26	0	7	1
27	0	8	1
28	0	9	1
29	0	10	1
30	0		
31	0.01		
32	0.01		
33	0.02		
34	0.05		
35	0.09		
36	0.17		
37	0.29		
38	0.46		
39	0.63		
40	0.78		
41	0.88		
42	0.93		
43	0.97		
44	0.98		
45	0.99		
46	1		
47	1		
48	1		
49	1		
50	1		

Figures

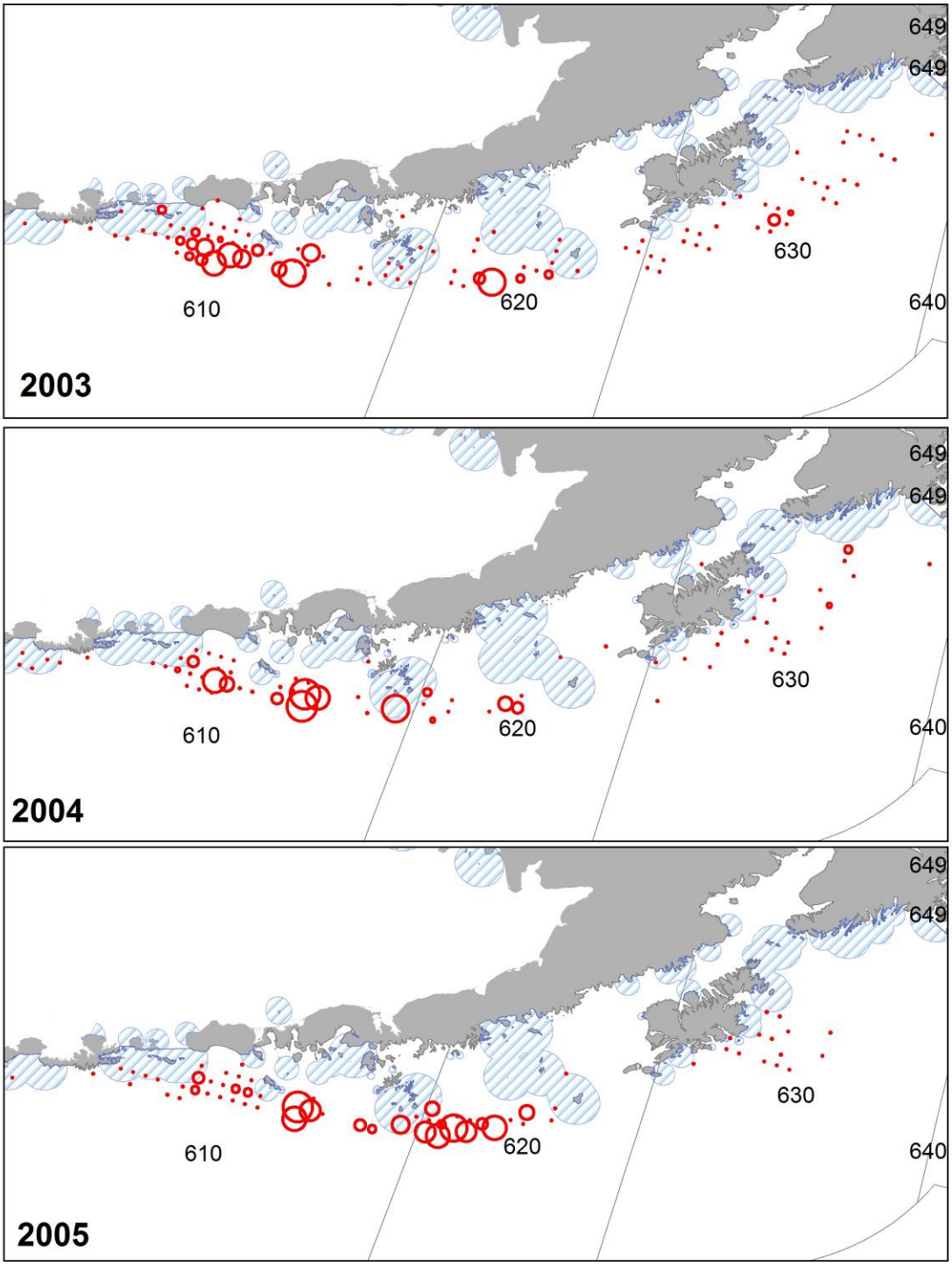

Figure 15.1. Observed catches of Atka mackerel in the 2003, 2004 and 2005 fisheries, summed by 20 km^2 cells. Open circles represent catches greater than 1 mt; closed circles represent catches less than 1 mt. Hashed circular areas represent no trawl zones.

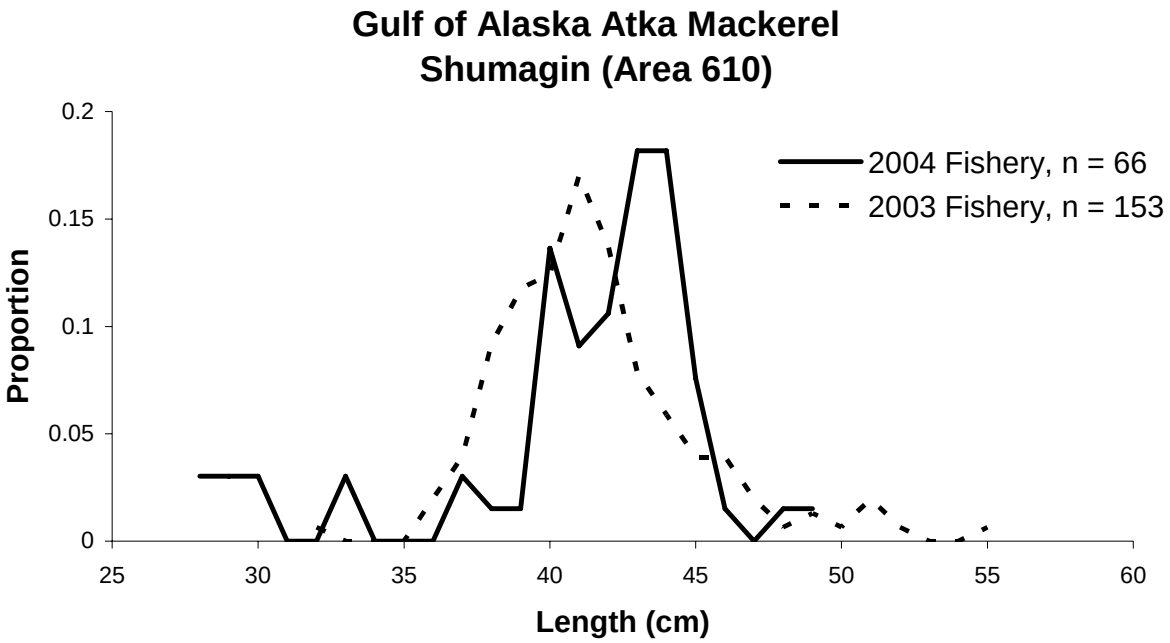

Figure 15.2. Fishery length frequency distributions of Atka mackerel from the Shumagin area from 2003 and 2004.

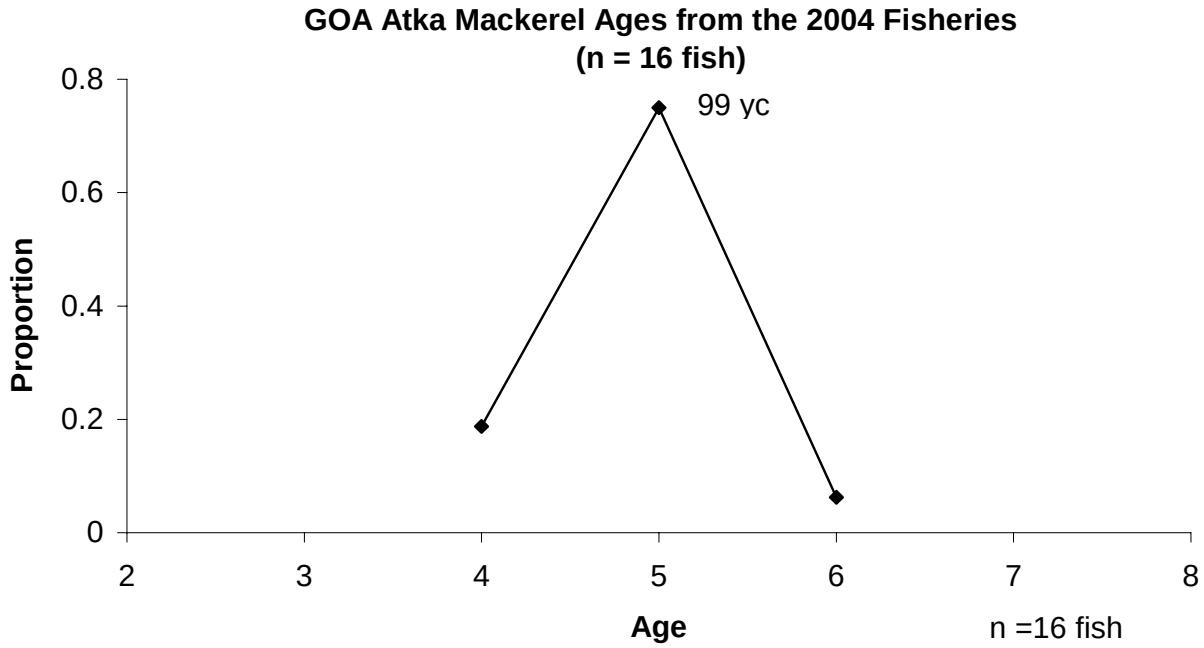

Figure 15.3. Atka mackerel age distribution from the 2004 fisheries.

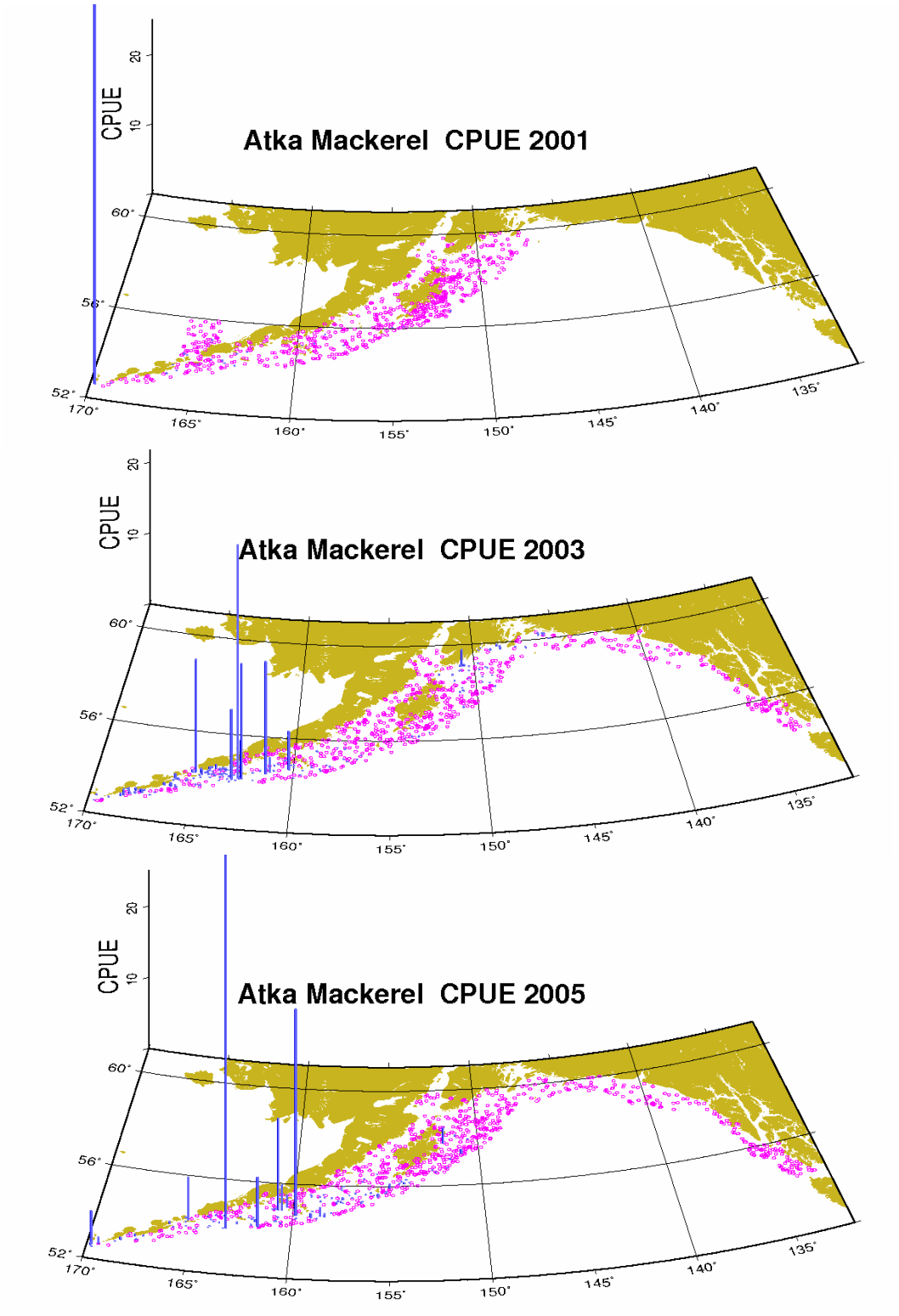

Figure 15.4. Atka mackerel bottom trawl survey CPUE by station, 2001, 2003, and 2005. Circles represent tows where Atka mackerel were absent, height of bars is proportional to CPUE by weight.

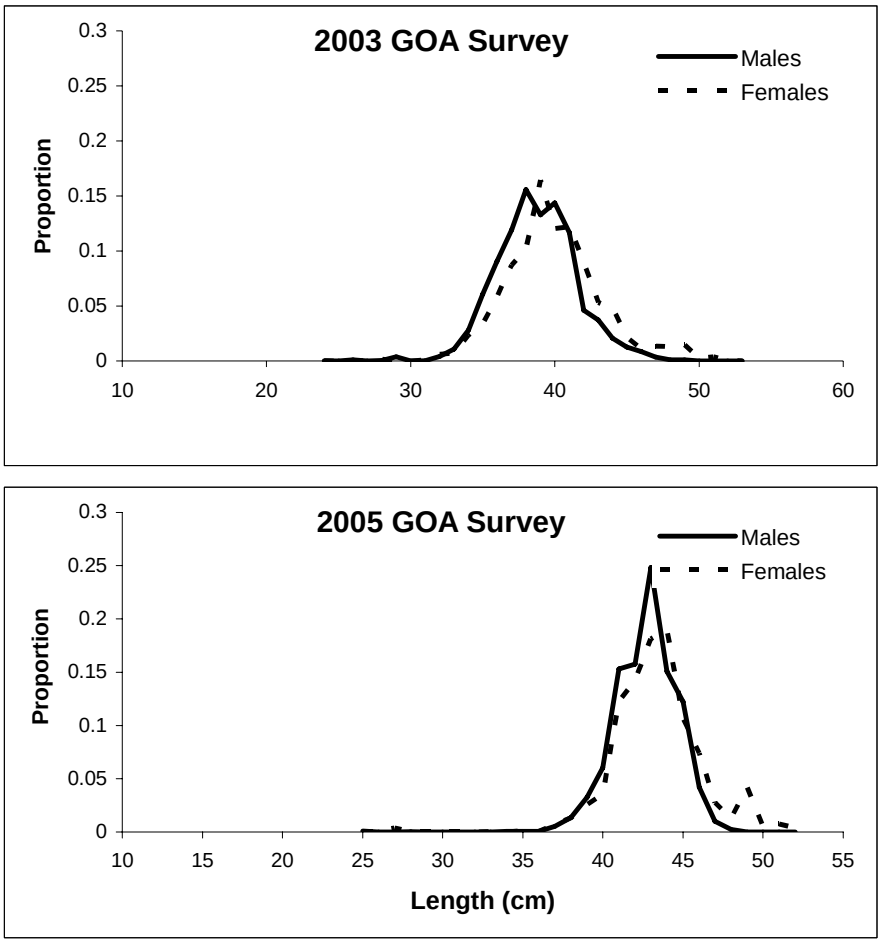

Figure 15.5. Atka mackerel length frequency distribution from the 2003 and 2005 Gulf of Alaska bottom trawl surveys.

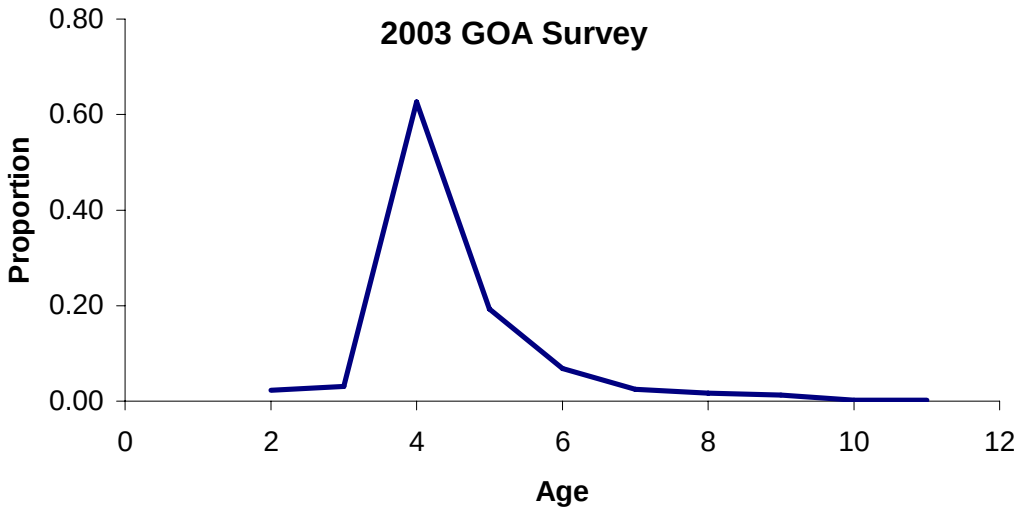

Figure 15.6 Atka mackerel age distribution from the 2003 Gulf of Alaska bottom trawl survey (482 fish were aged).